

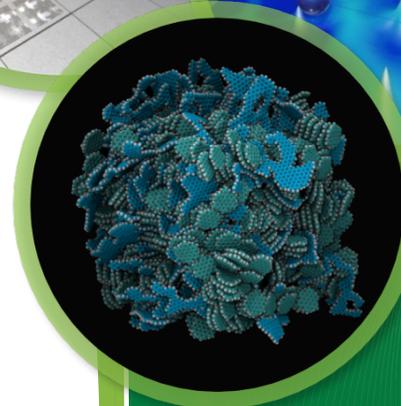
# Recent USNDP Astrophysics Activities

Michael Smith (ORNL), Chair Astro Task Force  
with contributions from

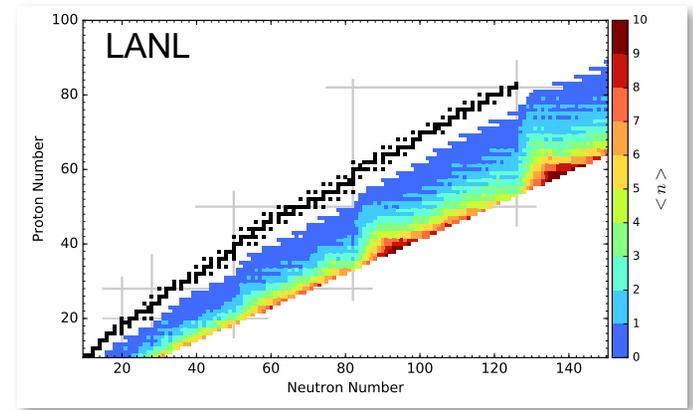
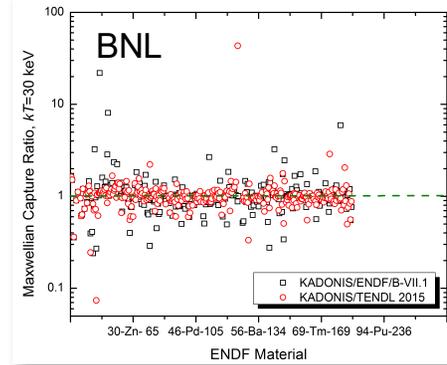
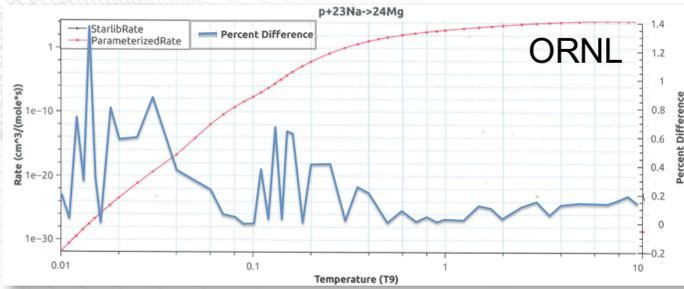
Boris Pritychenko (BNL)

Toshihiko Kawano (LANL)

Matthew Mumpower (LANL)



# Overview of Recent Astro Data Activities

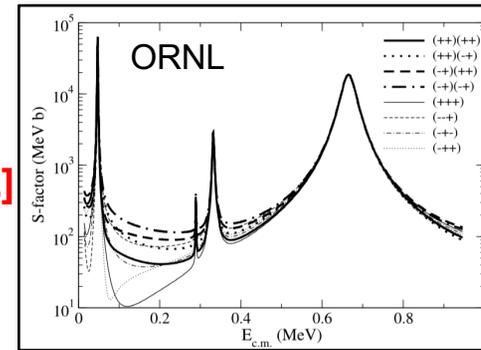


- **Generating reaction rates**

- processing TENDL-2015 cross section library into rates [BNL]
- parameterizing NACREII and STARLIB libraries into REACLIB format [ORNL]

- **Assessing Important Reactions**

- $^{18}\text{F}(p,\alpha)$  [ORNL]
- $^{19}\text{F}(\alpha,n)^{22}\text{Na}$  for long-lived  $^{22}\text{Na}$  production [ORNL]
- $^{124,126,128,130,130}\text{Sn}(n,\gamma)$  via (d,p) reactions [ORNL]



**Table 2**  
The resonance parameters used and varied in the calculation of the  $^{18}\text{F}(p,\alpha)^{15}\text{O}$  rate and its associated uncertainties. The ANC is given for the subthreshold resonance while other resonances are tabulated with their proton widths. Quantities come from measurements except where explicitly noted in the footnotes.

$E_{res}$ (keV)	$E_x$ (MeV)	$2J^\pi$	$\Gamma_p$ (keV) or ANC ( $\text{fm}^{-1/2}$ )	$\Gamma_\alpha$ (keV)
-124(3)	6.286(3)	$1^+$	83.5	$11.6^a$
7(3)	6.417(3)	$3^-$	$1.6 \times 10^{-41}$	$< 0.5^a$
29(3)	6.439(3)	$1^-$	$< 3.8 \times 10^{-19b}$	220
47(3)	6.457(3)	$3^{+a}$	$< 2.1 \times 10^{-13}$	$1.3^a$
289(3)	6.699(3)	$5^{+a}$	$< 2.4 \times 10^{-5a}$	$1.2^a$
332(2)	6.742(2)	$3^-$	$2.22 \times 10^{-3}$	$5.2^a$
664.7(16)	7.0747(17)	$3^+$	15.2	23.8
1461(19)		$1^+$	55	347

<sup>a</sup> Adopted from mirror level.  
<sup>b</sup> Based on assumed reduced proton width.

- **Theoretical input for rate determinations**

- Global calculations of beta-delayed neutron yields [LANL]
- Calculating photon strength functions for M1 scissors mode in deformed nuclei for (n, $\gamma$ ) rates [LANL]

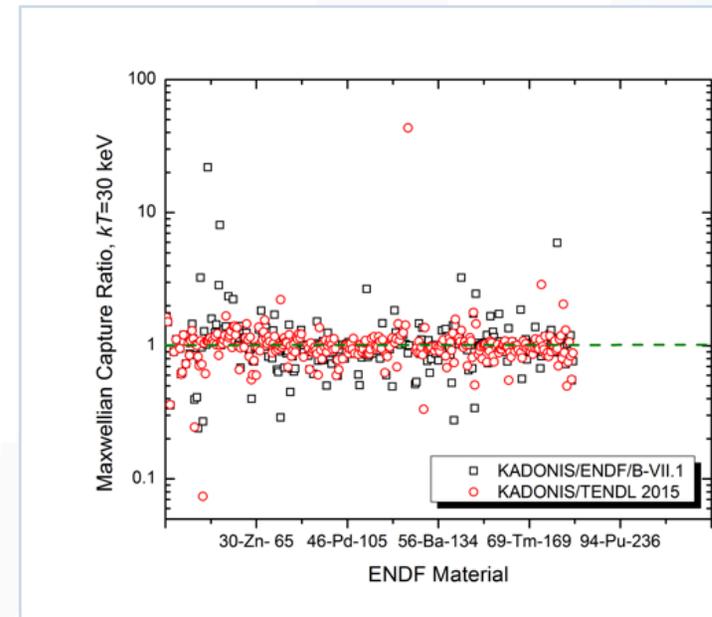
- Maintaining and Improving online software systems [ORNL] [NUCASTRODATA.ORG](http://NUCASTRODATA.ORG)

- Planning future activities / drafting whitepaper contribution [ORNL and MSU]

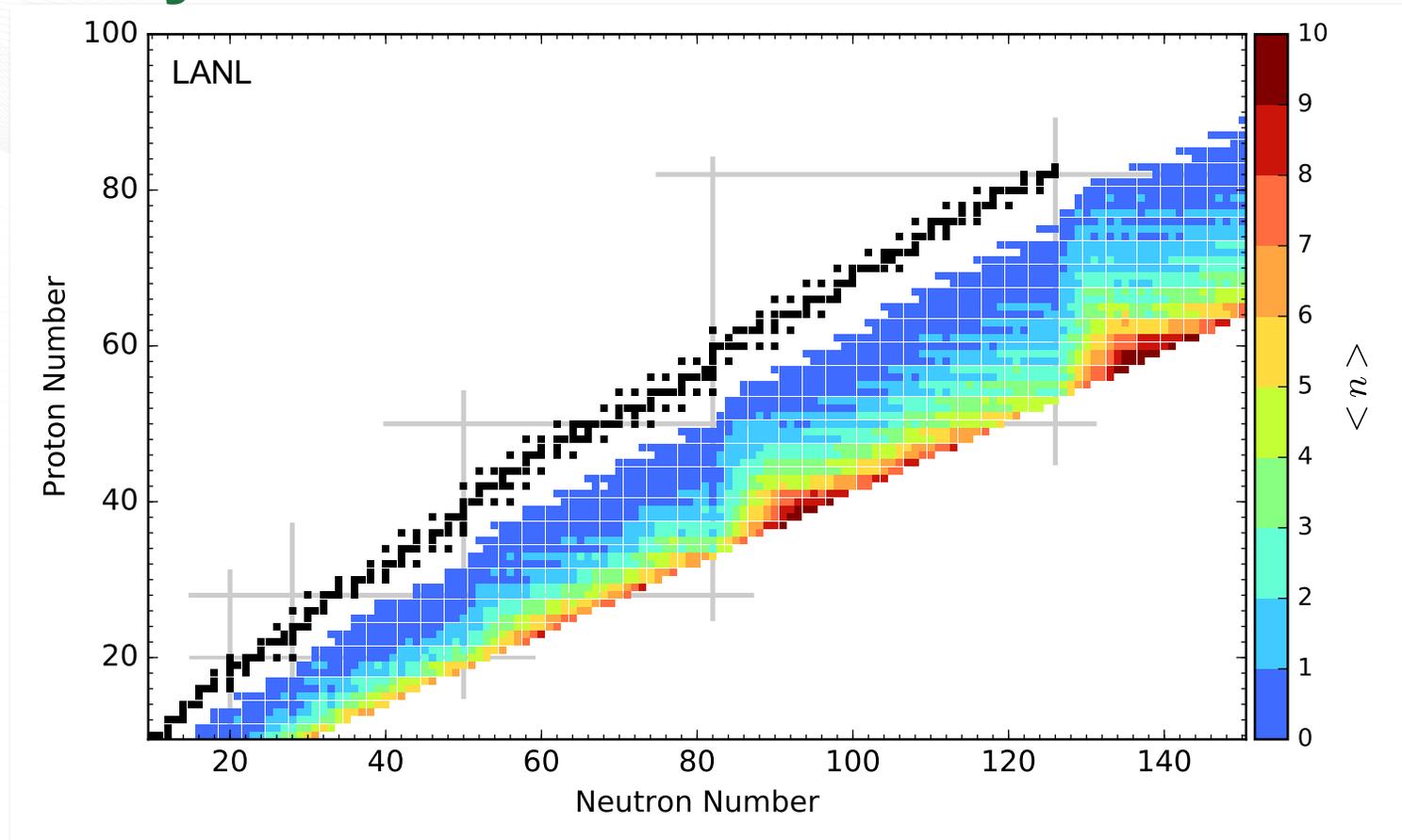
# TENDL 2015 vs. ENDF/B-VII.1

Boris Pritychenko  
NNDC, BNL

- TENDL 2015:
  - 2809 materials
  - Overall neutron library size: 14.8 GB
  - Doppler-broadened neutron library, 0.1%: 237 GB
  - Processing (Doppler broadening) time on Windows PC: 1-1.5 days
- ENDF/B-VII.1 is definitely better for Sr, Te, Sm and Hg. No difference for major actinides. In other cases TENDL is better.
- TENDL 2015 is better matched with theoretical values in KADONIS (NON-SMOKER calculations).



# Beta delayed neutron emission



- Beta delayed neutron emission crucial for calculations of r-process nucleosynthesis
- Global calculations of beta-delayed neutrons yields, and average neutron and photon energies, performed at LANL by Matthew Mumpower et al.
- Work submitted to PRC, work on beta-delayed fission ongoing

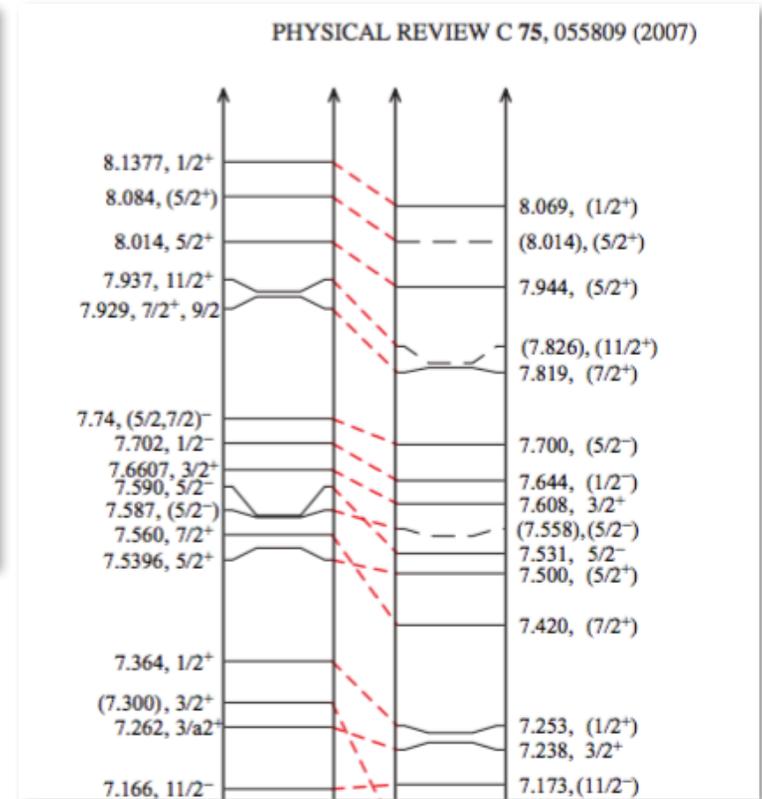
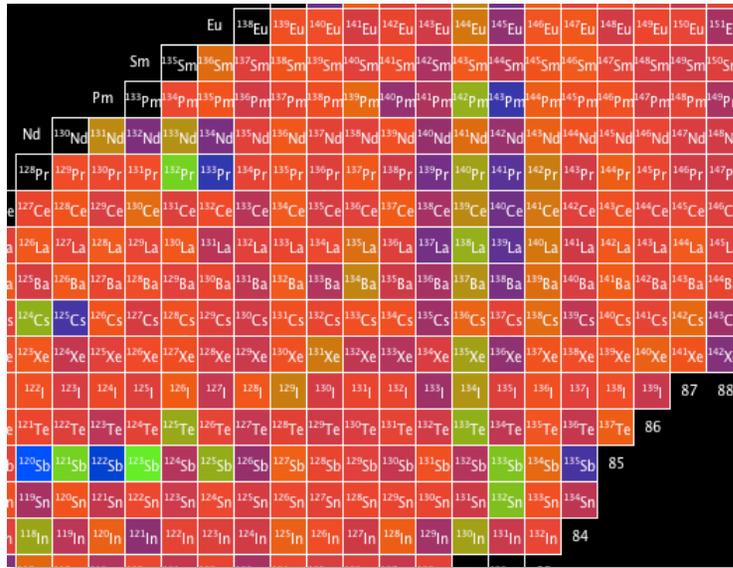
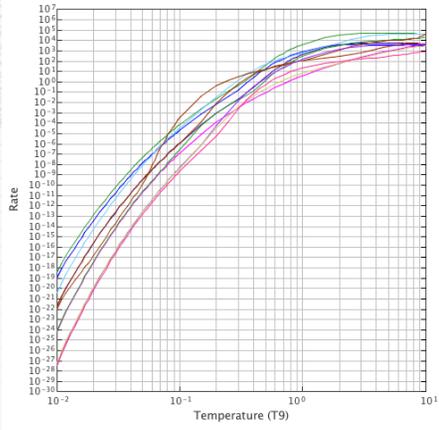
# Planning Future Activities

## Workshop for Nuclear Data Needs and Capabilities for Basic Science

August 10-11, 2016

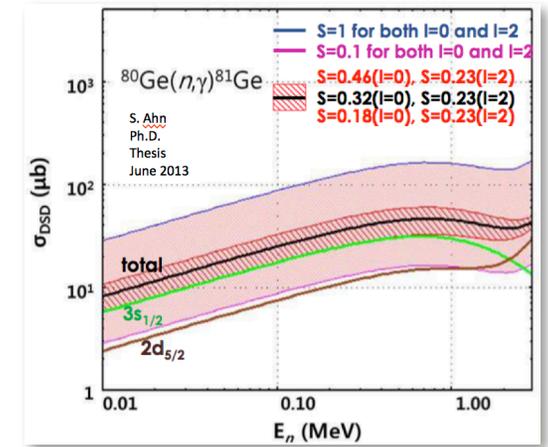
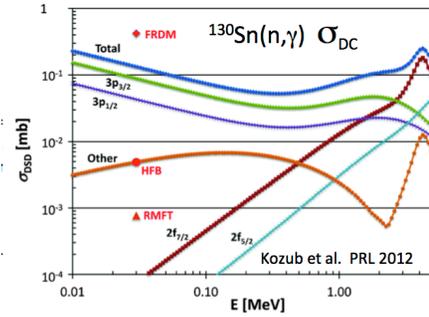
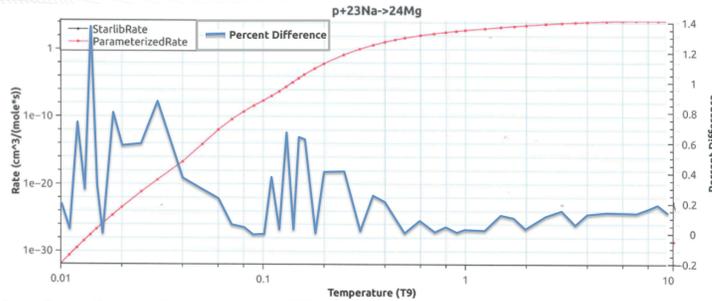
- August 2016 Workshop on Nuclear Data Needs for Basic Research included numerous talks on nuclear data for nuclear astrophysics
- Many comments at Workshop echoed the following:
  - tremendous excitement in nuclear astrophysics with new facilities, detectors, techniques
  - nuclear astrophysics is a “core” component of the field of nuclear science
  - **USNDP has not done enough to address data needs of nuclear astrophysics community**
- Later discussions (ORNL and MSU) led to Draft of Workshop White Paper section
- Draft included **overview** of data needs spanning many areas
  - Nuclear Reaction Data
  - Nuclear Structure and Decay Data
  - Reaction Rates and Other Specialized Nuclear Data Sets
  - Software and Dissemination
- Draft also included **prioritization, path forward, & specific recommendations**

# Priorities



- Data Priorities include
  - capture cross section evaluations
  - properties of low-lying single particle levels
  - cross sections and extracted level parameters from transfer reactions on unstable nuclei to indirectly determine capture reactions
  - nuclear masses for the entire nuclear chart
  - positron- and beta-decay lifetimes
  - processing, management, dissemination of thermonuclear reaction rates and rate libraries
  - global theoretical cross section calculations

# Recommended Path Forward



- Important to **enhance USNDP work in nuclear astrophysics data**
- Recommended that enhanced effort
  - should build on existing efforts
  - should be spread across different institutions
  - should focus on assessments of data most critical for astrophysics simulations
  - should include efforts to develop and spread special expertise for this work
  - must include development and maintenance of software and dissemination tools
  - should include robust storage solutions
  - should be flexible to evolve as data needs change in the field
  - should emphasize consistency across the field

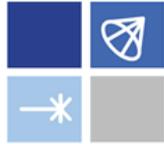


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# Specific Recommendations

JINA Reaclib Database

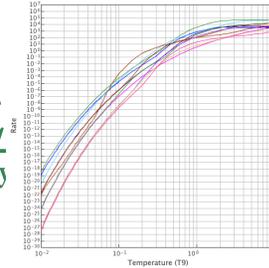


JINA-CEE

MICHIGAN STATE  
UNIVERSITY

NUCASTRODATA.ORG

OAK  
RIDGE  
National Laboratory



STARLIB: A NEXT-GENERATION REACTION-RATE LIBRARY  
FOR NUCLEAR ASTROPHYSICS

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- Specific Recommendations are
  - **Expand USNDP mission statement** to specifically **mention nuclear astrophysics**
  - **Expand USNDP activities** to include meeting the astrophysics data needs detailed above with efforts specifically **targeted for nuclear astrophysics**
- Recommended First Implementation
  - **Enhance evaluation** of astrophysical reactions by incorporating this into the work plan at the **MSU/FRIB Data Center**
  - **Enhanced software tool development** and maintenance by re-instating this activity in the **ORNL Nuclear Data Project**
  - Initiate the development of next generation reaction rate libraries by supporting work on **STARLIB** at the **NC State / TUNL Data Center** that would work closely with the JINA REACLIB effort at MSU capture cross section evaluations